Portable Automated Test Station: Using Engineering-Design Partnerships to Replace Obsolete Test Systems

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Abstract. The Air Force A-10C attack aircraft is currently experiencing obsolescence issues with its legacy support equipment. The Portable Automated Test Station Model 70 (PATS-70) replaces more than a dozen pieces of obsolete and irreparable flightline support equipment. The PATS-70 is a robust, flightline qualified test set that has gone through rigorous environmental testing. While it was developed to function as maintenance support equipment for the A-10C aircraft, it has no A-10 specific components so it can be adapted for maintenance on other aircraft, platforms, or systems.

Introduction

The Portable Automated Test Station Model 30 (PATS-30), Organizational (O)-Level test set is comprised of a COTS ruggedized Personal Computer using the Microsoft Windows XP operating system, a transport case, a cable set, and custom software. The PATS-30 functions as maintenance support equipment for the A-10C aircraft by performing maintenance activities and troubleshooting avionics system faults while the aircraft is on the ground.

The core component of the PATS-30, the ruggedized laptop, is no longer sustainable. Since the laptop is no longer available, the PATS-30 will no longer be supportable. Southwest Research Institute (SwRI) was tasked by the Air Force to address the end-of-life issues of the currently fielded PATS-30 and develop a proof of concept unit that performs the functions of the PATS-30. SwRI constructed one prototype, identified as the PATS-50 and field-demonstrated the prototype.

The PATS-50 proof of concept project demonstrated the feasibility of re-hosting the PATS-30 functions onto a different test platform. During the proof of concept project, some functionality was lost, the environmental requirements were not met, and additional requirements were identified. Analysis of the additional requirements relative to the PATS-50 was completed. The results of this analysis showed that the PATS-50 concept could be utilized and re-hosted onto a test station that included the lost functionality from the PATS-30, addressing the environmental requirements, and expanding capabilities to include several separate test systems that have been identified for inclusion into the PATS. This new design concept was designated the Portable Automated Test Station Model 70 (PATS-70) [1].

The PATS-70's modular design has been developed to meet the functionality requirements, environmental requirements, and additional expansion capabilities. The PATS-70 replaces more than a dozen pieces of obsolete and irreparable flightline support equipment. It has been organically developed using COTS components and industry standard software. An engineering-design partnership was formed between the Air Force and Marvin Test Solutions[1] to facilitate this development and to help the program meet its objective on-time, and on-budget. This led to the selection of the Marvin PXI-based, ultra-rugged MTS-207 platform, laying the ground work for PATS-70 instrumentation selections.

In addition, the PATS-70 provides flexibility over other test sets since the software architecture was uniquely designed for ease of adding additional Test Program Sets (TPSs) to support the war fighter's needs. Moreover, the PATS-70 hardware has spare capacity to add additional COTS PXI components to support future TPS development. With thousands of PXI cards available today, this provides the Air Force the necessary flexibility to tackle a multitude of test requirements and applications. The PATS-70 has also been selected as the test platform for a new A-10 weapons systems maintenance capability, merging the capability of eight legacy test sets along with additional flightline test capabilities into one test set.

The PATS-70 is a robust, flightline qualified test set which has gone through rigorous MIL-STD-810G, and MIL-STD-416F environmental testing. While it was developed to function as maintenance support equipment for the A-10C aircraft, it has no A-10 specific components so it can be adapted for maintenance on other aircraft, platforms, or systems. The flexibility and added functionality gives the PATS-70 an advantage in maintaining multiple systems throughout the Department of Defense.

System Overview

The PATS-70 is an automatic test system designed to perform functional tests on the Fairchild Republic A-10C Thunderbolt II's (A-10) Anti-skid, Alpha Mach, Stability Augmentation System (SAS), and Fuel Quantity Indicating System. The PATS-70 provides the logic and hardware control necessary to coordinate and automate control of these system functions. The PATS-70 is an automated, user friendly, state-of-the-art adaptable test set that provides robust system diagnostic capability, significantly reducing the time required to bring an aircraft into mission ready status. The PATS-70 provides a mission ready test set for the A-10 Command Center. The A-10 Aircraft Operational Test System (OTS) consists of a PATS-70, and the Operational Test Program (OTP). The OTS functions as maintenance support equipment for the A-10 aircraft. The OTS performs maintenance activities as well as trouble shooting avionics system faults while the aircraft is on the ground. The PATS-70 utilizes up-to-date, sustainable technology for Operational Flight Program (OFP) software loading and diagnostic avionics system testing and includes additional TPSs to enhance its capability while decreasing the A-10 maintainability footprint. To preserve combat effectiveness, and efficiency, the PATS-70 automates and consolidates multiple test capabilities into one mission ready test set. The PATS-70 is expandable to allow for the addition of future aircraft [2].

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14. ABSTRACT

The Air Force A-10C attack aircraft is currently experiencing obsolescence issues with its legacy support equipment. The Portable Automated Test Station Model 70 (PATS-70) replaces more than a dozen pieces of obsolete and irreparable flightline support equipment. The PATS-70 is a robust, flightline qualified test set that has gone through rigorous environmental testing. While it was developed to function as maintenance support equipment for the A-10C aircraft it has no A-10 specific components so it can be adapted for maintenance on other aircraft, platforms, or systems.

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Design

The PATS-70 is a portable field-level/O-level test set (see Fig. 1) capable of performing functional tests on aircraft systems. The test set is housed in an enclosure constructed of a durable composite material for protection and an embedded wire frame for electromagnetic interference (EMI) compliance. The enclosure consists of upper and lower sections secured together with eight (8) turn lock latches. A pressure-relief valve is located in the lower half of the enclosure. The PATS-70 is based on the Compact Peripheral Component Interface (cPCI or PCI); PCI eXtensions for Instrumentation (PXI) technology and includes a rugged 14-slot PXI chassis, power supplies, numerous circuit cards, wiring harnesses, cables for interfacing the test set with the Unit Under Test (UUT), heaters, fans, and other electrical and mechanical components [3].

Engineering-Design Partnership

An engineering-design partnership was formed between the Air Force and Marvin Test Solutions. Having extensive background and domain expertise with the development of test systems and test software, the 309th Software Maintenance Group was looking to partner with a company that had a similar level of domain expertise in flightline test and ultra-rugged test platforms. This led to the selection of the Marvin Test Solutions MTS-207 ultra-rugged PXI chassis. Having deployed flightline test sets in 20 countries in the past two decades, Marvin Test Solutions provided the platform and support to help the 309th SMXS deliver the PATS-70 on-time, and on-budget.

Hardware

The PATS-70 is PXI-based instrumentation platform. The circuit cards are COTS PXI products. PXI is an architecture for test and measurement applications that is based on the cPCI bus. This high-performance architecture provides for the throughput and synchronization required for the performance of precision measurements. The following list describes the main hardware components of the PATs-70 hardware.

Portable Automated Test Station, MTS-207-3 chassis - The Internal Chassis Assembly is the main assembly of the MTS-207-3. It "hangs" from the top panel of the MTS-207-3 accommodating connectors, switches, etc. via four (4) shock absorbers designed to protect the internal electronics. The Internal Chassis Assembly accommodates all the MTS-207-3 electronics. Its main assemblies are the PXI card cage, and the Power Board circuit card assembly (CCA). The Power Board provides all required PXI chassis power rails as well as additional supplies required for the operating of the display and peripheral PATS-70 equipment. Additionally, the Power Board provides control over the MTS-207-3 heaters, allowing operation at extreme low temperatures. The EMI Filter protects the MTS-207-3 from power surges and eliminates conducted emissions, to ensure compliance with MIL-STD-461 requirements.

User Interface Display (Tablet) – A modified Miltope RTCU-2 Tablet computer is used as the operator console. The Tablet is powered by a 1.06 GHz Intel Core i7-620UE processor with 4MB L2 Smart Cache and 8 GB of RAM. The Tablet is dock mounted or extended on the supplied user interface cable. The Government modification of the tablet allows for external connection utilizing reliable MIL circular connector technology.

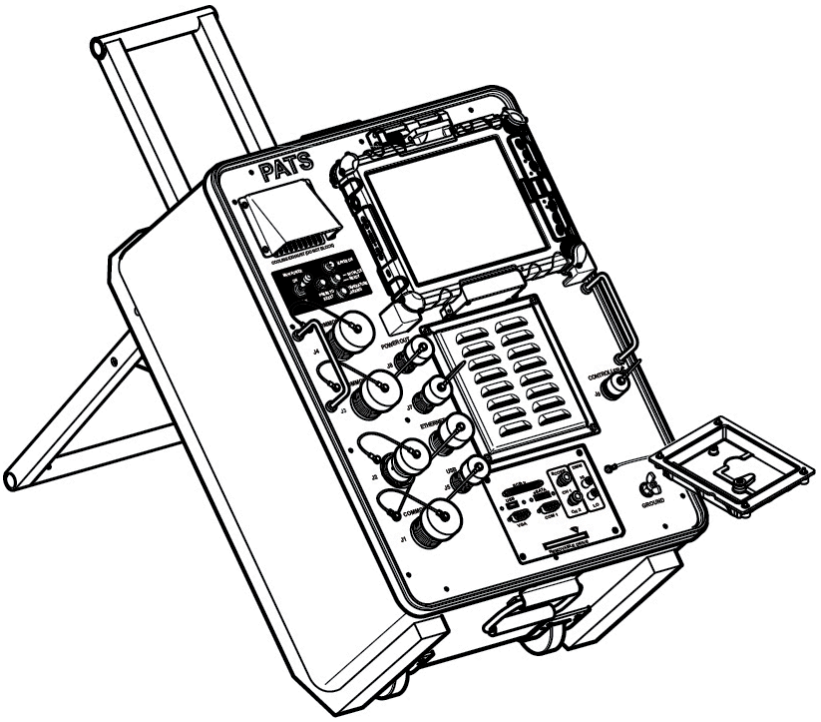

Figure 1. PATS-70 Hardware

Removable Solid State Hard Drives – The removable storage device is a minimum of 120 GB Solid State Drive (SSD); it is mounted inside the case via a drive slot on the face of the chassis, or stored in the engineering panel cover. It is configured with Windows XP or Windows 7 OS and allows integration of classified software when required.

Controller CCA- This controller contains a 2.53 GHz Intel i7 core processor with 4GB Random Access Memory (RAM). Utilizing the rear transition module, this CCA has four Gigabit Ethernet ports, two VGA ports, five USB ports and two RS232 ports, in a 6U cPCI module.

45 Relay Form C CCA - The Form C relay matrix for the high current switching requirements includes 45 single pole double throw Form C relays with 7A contact rating per channel in a 6U PXI module.

8x132 2AMP Relay Matrix CCA – This is a very high density electro-mechanical relay matrix with a 132x8 format and 1 pole switching. The matrix is constructed using high reliability 2A electro-mechanical relays with long life and stable contact resistance and is a single slot, 6U PXI module.

1553 Communications CCA – The communications card supports up to 4 dual redundant 1553 channels. Each channel operates simultaneously as a bus controller, bus monitor and remote terminal in a 3U PXI module.

Digital Multi-Meter (DMM) CCA – The 6.5 digit multi-meter is capable of true AC RMS measurements from 10Hz to 100 KHz, measures 1uV to 330V, frequency counting from 1Hz to 300 KHz in a 3U PXI module. The DMM supports Volts DC, Amp DC, Two-Wire Resistance, Four-Wire Resistance and Frequency measurements, in a 3U PXI module.

Small Computer System Interface (SCSI) CCA – A single channel SCSI interface, supports up to 320MB/s throughput; it is backwards compatible with ultra2 SCSI and is a 3U PXI module.

Differential Oscilloscope CCA – A 2 channel 14 bit resolution, 300MHz bandwidth digitizer features a maximum sample rate of 400MS/s and is a 3U PXI module.

Arbitrary Waveform Generator (ARB) CCA – A 2 channel 14 bit resolution, 50 MHz bandwidth waveform generator features a maximum sample of 200MS/s and is a 3U PXI module.

Software

The software subsystem consists of four software layers; the Operating System, the Device and Instrument Drivers, Test Executive Software, and the Test Programs as shown in Fig. 2. Each layer is a building block for the next layer.

Operating System - comprised of COTS software that is provided on each PATS-70 System. The PATS-70 uses two removable Solid State Hard drives (SSD); one containing the Windows XP Operating System (OS) and one with the Windows 7 OS. Different sets of tests are available depending on the OS currently loaded. TPS test programs, PATS-70 Self-

Test, and System Calibration all run under the Windows 7 OS. The A-10 Operational Test Program (OTP) runs under the Windows XP OS and contains its own Self-Test function built into the OTP software.

Device Drivers and Instrument Wrappers - includes any software that initializes and controls specific system interfaces between the system controller and system devices.

Test Executive Software - includes the requisite COTS software used to create and modify test programs.

Test Programs - specific programs designed to test and manipulate the UUT. Two of these TPSs are the Alpha Mach and Anti-Skid which are software that can be loaded on the Windows 7 System SSD. The Alpha Mach and Anti-Skid TPSs are used to conduct diagnostic tests for the Alpha Mach and Anti-Skid systems on the A-10.

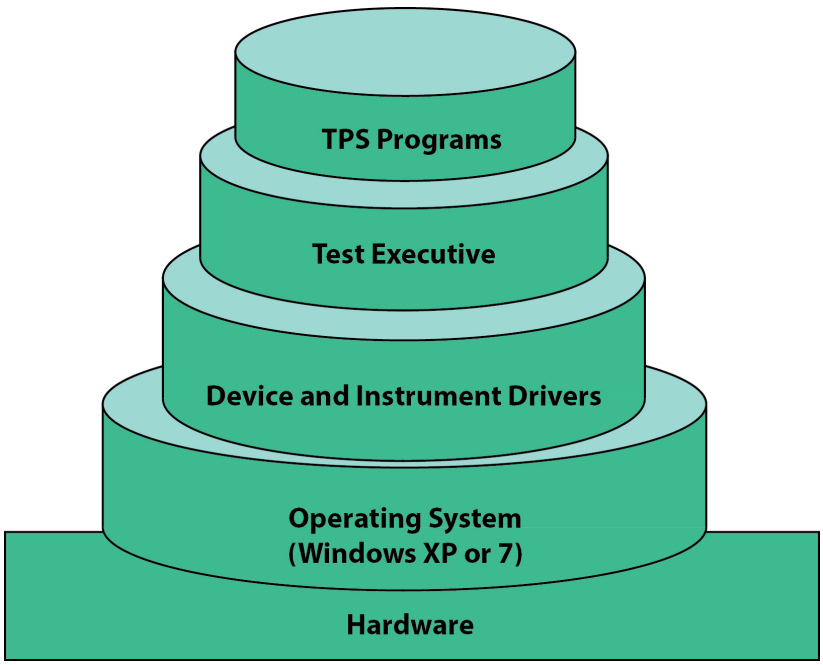

Figure 2. System Software

In addition, there are two other software components incorporated in the PATS-70 system:

Self-Test - tests the PATS-70 and identifies the faulty replaceable subassembly such as the arbitrary waveform generator, digital multimeter, and oscilloscope.

System Calibration - tests the PATS-70 against a defined performance standard and identifies the faulty replaceable subassembly. PATS-70 calibration determination has been approved and listed by Air Force Metrology and Calibration (AFMETCAL). PATS-70 calibration traceability and configuration management is accomplished through an automatic calibration routine, approved Computer Program Identification Number (CPIN), and calibration procedures.

Applications

The PATS-70 attaches to the A-10C aircraft through a variety of TPS connections in which applicable tests are run to track down and identify issues. In addition, the PATS-70 test set has the ability to perform firmware and/or Operational Flight Program (OFP) loads to the Integrated Flight and Fire Control Computer (IFFCC), Central Interface Control Unit (CICU), Improved Electronic Processor Unit (IEPU), and download Non-Volatile Memory (NVM.) The PATS-70 consolidates a wide variety of avionic specific support equipment and software into a single test unit.

The current software available on the PATS-70 to maintain the aircraft consists of the Operational Test Program (OTP), Alpha Mach, and Anti-skid TPSs which are described in the following.

Operational Test Program

The OTP TPS is software that can be loaded onto the Windows XP System SSD. The OTP is used to conduct diagnostic tests for avionics and weapons stations of the aircraft and to load OFPs.

Alpha Mach

The Alpha Mach TPS is used during flightline test of the A-10C aircraft to isolate anomalies in the Alpha Mach computer and its related components.

The Alpha Mach is part of the secondary flight control system. It receives air pressure and lift data to operate the leading edge slats and automatically improve high angle of attack airflow to the engines. The system also provides audible warnings to the pilot for engine peak performance and impending stall situations.

Anti-Skid

The Anti-Skid Control System TPS is used during flightline testing of the A-10C aircraft as the Anti-Skid operational check and to troubleshoot and isolate Anti-Skid Control System anomalies.

The Anti-Skid Control System is a modulating wheel skid control system which proportionately reduces the amount of left hydraulic system pressure supplied to both main landing gear brakes when either main wheel begins to skid.

Enhanced Capabilities and Applications

Stability Augmentation System

The Stability Augmentation System (SAS) TPS is used during flightline test of the A-10C aircraft to isolate anomalies in the SAS computer and its related components.

The purpose of the SAS is to improve the stability and handling quality of the aircraft, especially in low altitude, high angle-of-attack situations. The computer, a part of the stability augmentation system, contains sensors and electronic circuits to amplify and modify sensor signals. The computer interfaces with the Low Altitude Safety and Targeting Enhancement (LASTE) computer for further processing of the pitch, roll, and yaw rate data. The LASTE computer sends its signals to the SAS computer which drives aircraft actuator devices in the pitch and yaw axes. Contained in the test sequence are directives for hardware resource control which are sent to the Test Executive Program. When directed to perform a measurement, the Test Executive Program returns measurement data which is compared with test limits contained in the test sequence to determine a GO or NOGO result. The test description, limits and GO/NOGO results are then passed back to the Test Executive Program for display on the PATS-70 [2].

Fuel Quantity Indicating System Tester

The A-10 Fuel Quantity Indicating System (FQIS) consists of capacitive fuel probes and compensators, a fuel quantity intermediate device (FQID), an indicator, and associated wiring harnesses. The FQID has a pivotal role in the fuel quantity system. Its purpose is to monitor tank probes and compensators to gather fuel information. It generates analog voltage signals proportional to the fuel quantity and sends these to an external indication device (fuel quantity indicator) [4].

The FQIS Tester is designed for use with the PATS-70 tablet. The tester measures fuel probe and compensator capacitances and harness insulation resistance; simulates the tank probe capacitances at empty, full, and unbalanced; and stimulates the FQID and fuel quantity indicator. This allows for full calibration, testing, and troubleshooting of the FQIS.

PATS-70A

The 309th Software Maintenance Group is currently developing the PATS-70A which will consist of a modified PATS-70 Core Unit, PATS-70A Auxiliary Unit, and equipment interface cables. The modification of the Core Unit includes adding several additional PXI cards and the associated wiring harnesses and software changes. Since the PATS-70 is based on a COTS platform and the PXI standard, these modifications require a minimal effort and demonstrate the adaptability of the PATS-70 [5].

The PATS-70A is designed to provide in-depth testing and troubleshooting functions to support a variety of A-10 armament related Line Replaceable Units (LRUs) at both the flightline and Intermediate (Back shop) levels. The testing functions to be provided by the PATS-70A include:

1. PATS-70A System Calibration
2. PATS-70A System Self-Test
3. Digital Data Processing Unit (DDPU)
4. Dual Rail Adaptor (DRA)
5. DRA w/ Launcher Unit (LAU)105's attached
6. Electronic Gun Control Unit (EGCU)
7. Electrical Test Panel (ETP)
8. LAU-105/A Guided Missile Launcher
9. LAU-117A(V)3/A Guided Missile Launcher
10. LAU-131/A Rocket Launcher
11. LAU-88A/A Guided Missile Launcher
12. Munitions Armament Unit (MAU)-40/A Bomb Ejector Rack
13. MAU-50/A Bomb Ejector Rack
14. Modified Triple Ejector Rack (TER)-9A (Digital TER)
15. Triple Ejector Rack (TER)-9A
16. Pylon Wiring-Weapons Station 1/11
17. Pylon Wiring-Weapons Station 2/10
18. Pylon Wiring-Weapons Station 3/9
19. Pylon Wiring-Weapons Station 4/8
20. Pylon Wiring-Weapons Station 5/7
21. Pylon Wiring-Weapons Station 6
22. Station Control Unit A (SCU-A)
23. Station Control Unit B (SCU-B)
24. DRA Wiring Harness
25. Gun, Aircraft Unit (GAU)-8A_Wiring&Sensors
26. Guided Missile Interface Unit (GMIU)
27. LAU-105_Power Supply
28. LAU-105_Wiring Harness
29. LAU-117_Launcher Electronic Assembly (LEA)
30. Modified TER-9A Electronic Control Unit Rack Kit
31. TER-9A Wiring Support Assembly
32. A-10C Armament Wiring

Future Growth

The PATS-70 is a robust, flightline qualified test set which currently functions as maintenance support equipment for the A-10C aircraft. Yet it has no A-10 specific components so it can be adapted for maintenance on other aircraft, platforms, or systems such as helicopters, tanks, or armored vehicles.

The PATS-70 also has vast potential as an intermediate back shop tool. The PATS-70A development will support testing of armament related LRUs. This functionality can be augmented to include a variety of DoD LRUs and Weapons Replaceable Assemblies (WRAs).

Summary

The PATS-70 started deployment earlier this year having successfully completed a rigorous qualification and validation phase in 2013. The PATS-70 program demonstrated that Engineering-Design partnerships and cooperation can help the Government to better support the warfighter. By partnering with Industry and combining the domain expertise of the 309th and Marvin Test Solutions, the Air Force was able to deploy a PATS-70 test set that meets the warfighter's needs on-time and on-budget.

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NOTES

1. All references to Marvin Test Solutions and/or Marvin products are provided for technical purposes only; no commercial endorsement is implied or intended.